

**Advanced Emission Control
Technologies
for
Gasoline-Powered Passenger Cars
and
Light-Duty Trucks**

MECA, April 1997

Gasoline Light-duty Emission Technology

- Technology renaissance “triggered” by California LEV/ULEV program
- Technology development remains on schedule
- Technologies can be applied to higher weight class vehicles
- Continued cost reductions realized over time
- Levels even below ULEV stds. are within reach

Emission Control Technology Challenges

- Cold-start hydrocarbon emissions
- Ultra-low NOx emission performance
- Extended durability requirements
- Capable diagnostic systems

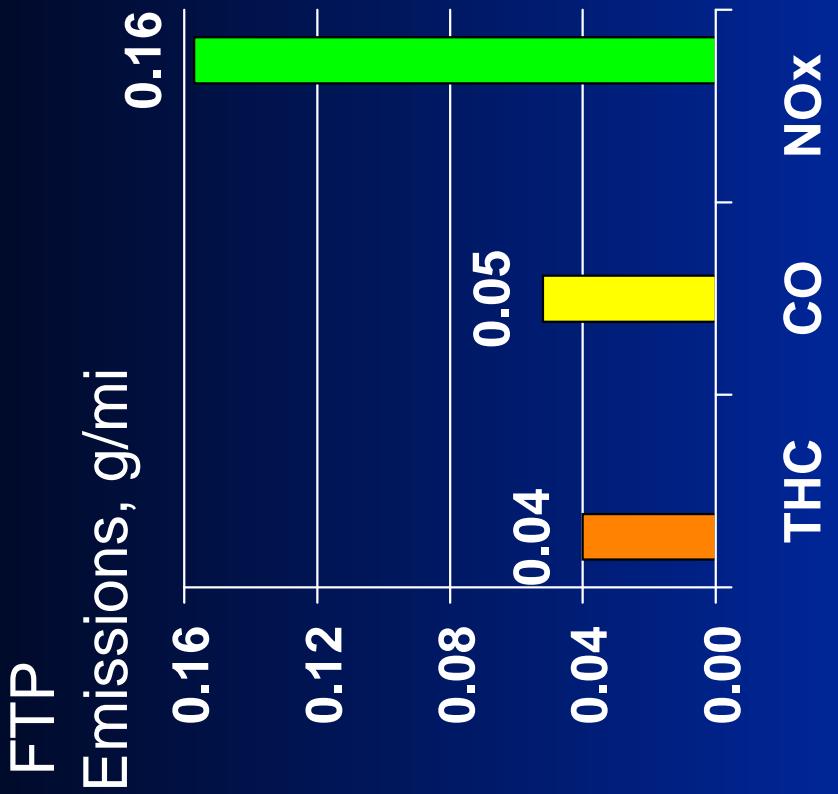
Advanced Emission Technologies

- High performance catalysts
- Advanced substrate designs
- EHCS
- Hydrocarbon adsorbers

High Performance Catalysts

- Engineered catalysts
 - Multi-component/multi-layer systems
 - Tailored oxygen storage functions
- Improved high temperature stability
- Improved performance in the presence of sulfur

ULEV Performance with Passive Technology



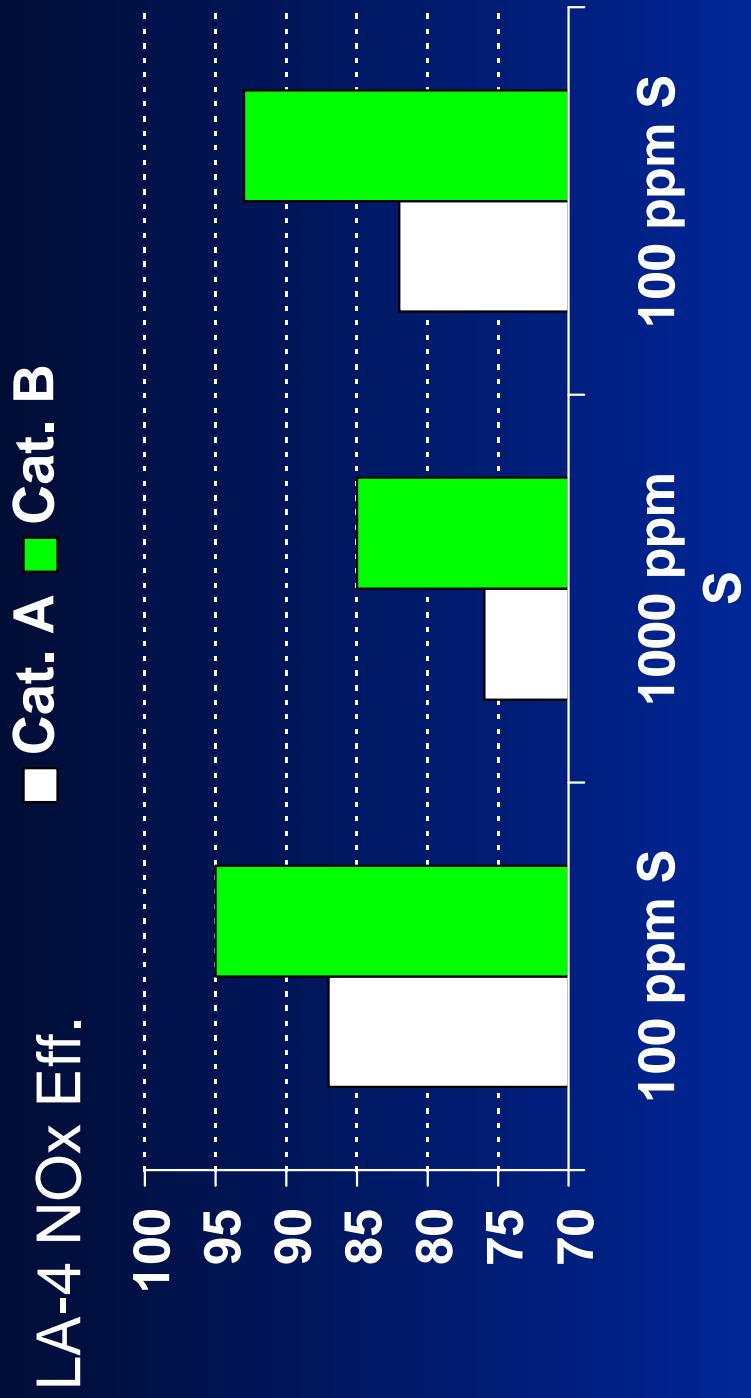
- 2.8 liter V6 with sec. air & adv. calib.
- Dual 400 cpsi metal LOs (engine-aged) + 100K mi AMA-aged ceramic UF
- Layered Pt/Pd/Rh cat

Pd+Pd/Rh LEV Converter Extended Durability 5.7 liter MDV2 V8, Dual Conv. (1.2 liter ea)



MDV2 LEV stds @ 120K = 0.23 g/mi NMOG, 0.6 g/mi NOx

Pd-only Aged Catalyst Performance Sulfur Effects



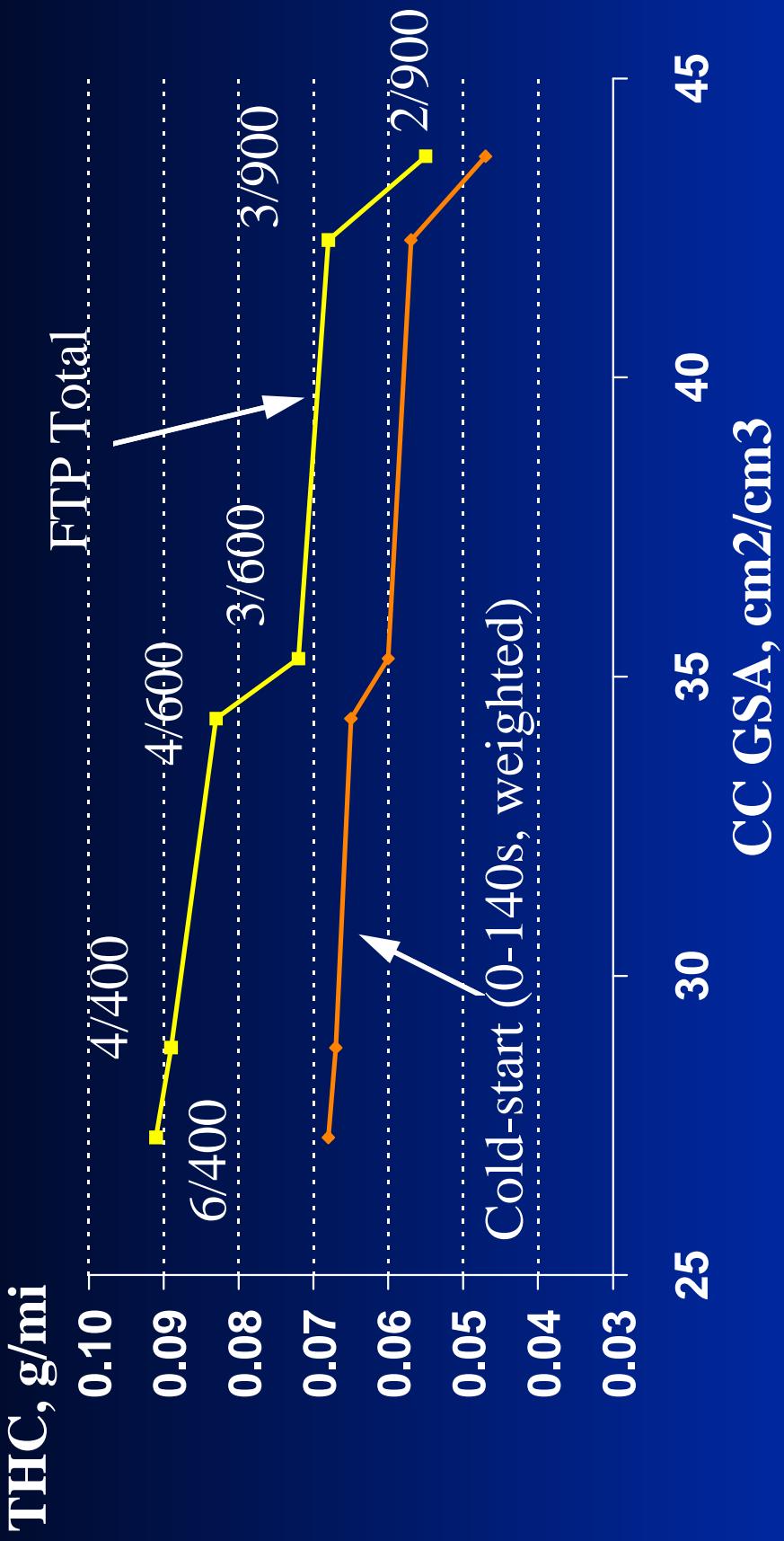
Ultra-low NO_x Strategies

- Combining tailored, high performance catalysts with advanced engine controls and leak-free exhaust systems
- Advanced engine controls include:
 - Adaptive transient air/fuel algorithms
 - Dual oxygen sensor strategies
 - Electronic EGR
- Significant development efforts continue on lean NO_x catalyst and NO_x adsorber technologies

Advanced Substrate Designs

- Ceramic systems
 - Ultra-high cell densities with thinner walls
 - Improved high temperature mounting schemes
- Metallic systems
 - Ultra-high cell densities
 - Perturbed flow paths for improved gas contact
 - Pre-coated foil systems with improved washcoat distributions

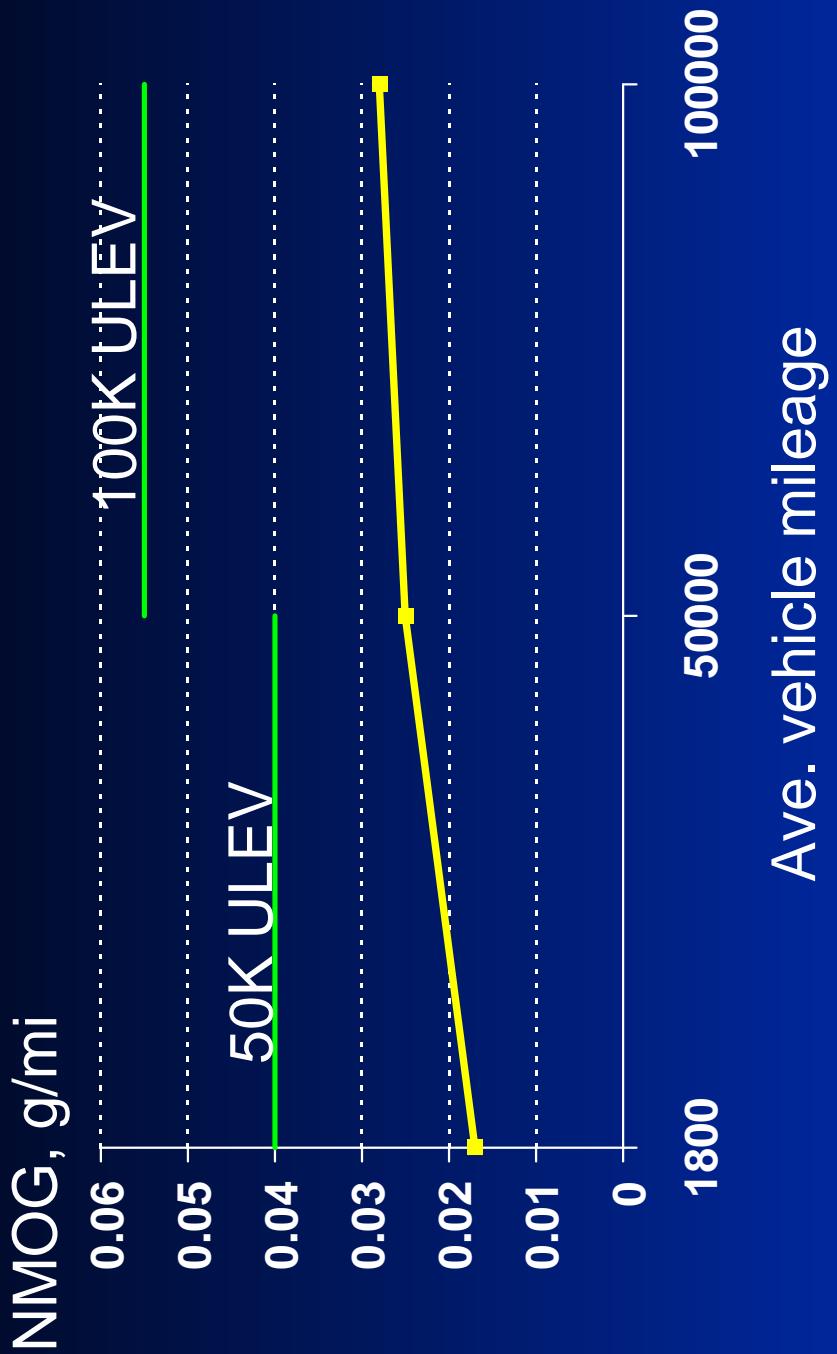
Ceramic Monolith GSA Influence on THC Emissions (CC+UF system)



EHC Technology Update

- First commercial EHC system offered in Europe during 1996 - BMW Alpina V-12
 - dual, 12V system
 - ca. 100 vehicles, 20K km/30K cold starts
- 100K mi EHC fleet test completed
 - 16 2.2 & 4.6 liter vehicles with 30V EHC

100K Mile EHC Test Fleet NMOG Emissions



Hydrocarbon Adsorbers

- Adsorbers “trap” hydrocarbons during cold-start (zeolitic materials)
- Systems under development
 - In-line adsorbers integrated with LO and UF converters
 - Trap material integrated into washcoat
- Focus includes durability, packaging optimization, & diagnostic strategy

Emission Control Cost Reductions

- Continued system cost reductions realized over time
- Optimization & simplification of emission control strategies/technologies

Gasoline Emission Control Technology Summary

- Gasoline vehicles continue to dominate fleet
- Catalysts with improved performance & durability available
- Greater variety of substrates available for additional design flexibilities
- EHCs ready for commercial applications

Gasoline Emission Control Technology Summary

- Adsorber systems continue to evolve
- Technology costs well below initial industry estimates
- Technology developed for passenger car applications can be optimized for other vehicle applications
- Technology can help reduce emissions well below the current Federal Tier I levels